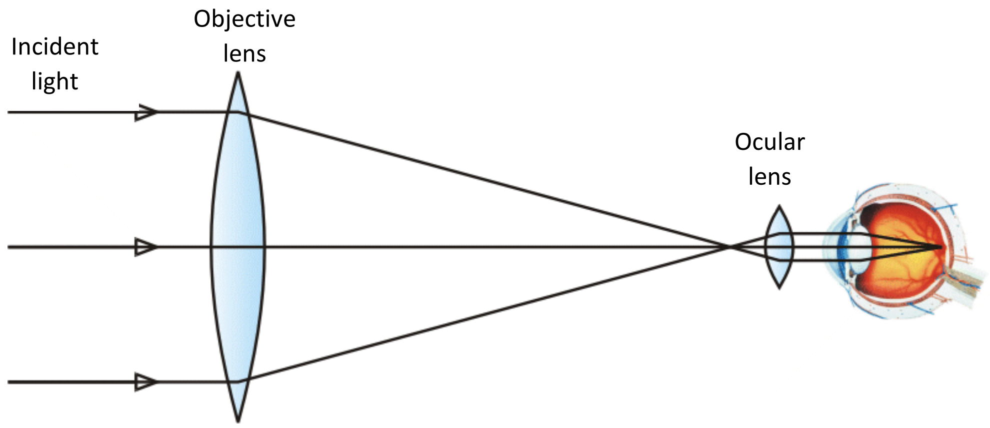
I. Multiple choice problems – 100 points

For these problems, you have to choose only one correct answer. Please write your answer on answer-sheet. **Don't forget to write the number of the problem, i.e Grid 1. (c).**

Grid 1. The stars observed with the telescope

The diameter of the objective lens of a telescope, represented in the drawing in figure 1, is $D_{\text{objective telescope}} = 300$ mm, and the diameter of the pupil of the observer's eye is $D_{\text{pupil eye}} = 6\,\text{mm}$.

The light gathering power, coming from a star, due to this telescope, is:



a) $g_c = 2500$; b) $g_c = 1500$; c) $g_c = 1000$; d) $g_c = 3000$.

Grid 2. The Sun on the Horizon

The astronomical refraction correction, ρ_r, has the minimum value, $\rho_{r,\min} = 0$, when the star is at the zenith of the Earth's surface observer $(z = 0; h = 90^0)$, and has the maximum value, $\rho_{r,\max}$, when the star, whose light passes through the Earth's atmosphere, in order to reach the Earth's surface observer, is at the horizon $(z = 90^0; h = 0)$, that is, when the star rises or sets.

It is known, that for an observer, atmospheric refraction raises the Sun in the moments of sunrise and sunset, that is, when it is below the horizon, approximately at its edge, by an apparent disk.

It is given: the radius of the Sun, $R_S = 6.96 \cdot 10^5\ km$ the distance between the centre of the Earth and the centre of the Sun, $d = 15 \cdot 10^7\ km$.

The value of $\rho_{r,max}$,is:

a) $\rho_{r,max} \approx 23.7'$ b) $\rho_{r,max} \approx 43.7'$ c) $\rho_{r,max} \approx 53.7'$ d) $\rho_{r,max} \approx 33.7'$

Grid 3. The escape velocity

It is given: $V_0 \approx 30\,\frac{\text{km}}{\text{s}}$, the speed of the Earth in its circular orbit around the Sun; $v_0 \approx 7.9\,\frac{\text{km}}{s}$, the speed of a terrestrial satellite orbiting the Earth in a very low circular orbit (the first cosmic speed).

It is known that: $\frac{M_{\text{Earth}}}{R_{\text{Earth}}} << \frac{M_{\text{Sun}}}{R_{\text{Earth-Sun}}}$.

The variation of the kinetic energy of the body, in relation to the Sun, is neglected during the motion of the body from the surface of the Earth to the limit of the gravitational attraction of the Earth.
The approximate minimum escape velocity of a body B, relative to the Sun, launched at a distance from the Sun equal to *1 AU*, so that it leaves the Solar System forever, is:

a) $v_B \approx 45.52\,\frac{\text{km}}{s}$ b) $v_B \approx 32.32\,\frac{\text{km}}{s}$ c) $v_B \approx 22.22\,\frac{\text{km}}{s}$ d) $v_B \approx 42.42\,\frac{\text{km}}{s}$.

Grid 4. The Terrestrial Satellite

A small satellite (a luminous sphere) that orbits the Earth, in an equatorial circular orbit at the altitude h, is photographed with a camera on the ground, the lens of which is a converging lens with focal length f. The photography is made when the satellite aligns with the camera and the centre of the Earth.

It is given: the mass of the Earth, M; the gravitational constant, *G,* the radius of the Earth, *R*. During the photographic exposure the proper rotation of the Earth is neglected.

The length of the image on the photograph, after developing the photographic plate, placed in the focal plane of the objective lens, as indicated by the drawing in figure 1, if the exposure time of the camera was Δt, is given by the expression:

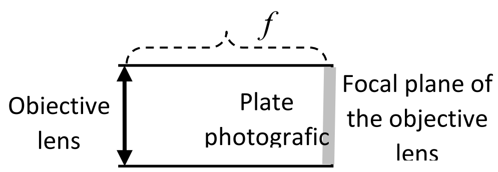


Fig. 1

a) $l = \frac{f}{h-f} \cdot \sqrt{G \frac{M}{R+h}} \cdot \Delta t$ b) $l = \frac{f}{h+f} \cdot \sqrt{G \frac{M}{R+h}} \cdot \Delta t$ c) $l = \frac{f}{h-f} \cdot \sqrt{G \frac{M}{h-R}} \cdot \Delta t$ d) $l = \frac{f}{h-f} \cdot \sqrt{2G \frac{M}{R+h}} \cdot \Delta t$

Grid 5. Andromeda Galaxy Rotation

The following are known: the Earth – Andromeda galaxy distance, $R = 1.42 \cdot 10^{11} R_0$, where R_0 is the radius of the Earth's circular orbit around the Sun; the mass of our Galaxy, $M_G = 2.5 \cdot 10^{11} M_0$, where M_0 is the mass of the Sun; $T_0 =$ 1 terrestrial year, the period of rotation of the Earth around the Sun; the mass of the Andromeda galaxy, $M_A = 3.6 \cdot 10^{11} M_0$.
The period of the rotational motions of our galaxy and the Andromeda galaxy, around their common centre of mass, is:

a) $5.1 \cdot 10^{10}$ years b) $6.9 \cdot 10^{10}$ years c) $7.9 \cdot 10^{10}$ years d) $8.2 \cdot 10^{10}$ years

Grid 6. The Sun as seen from Saturn

It is known that: the distance Saturn - Sun is 9.54 times greater than the distance Earth - Sun; the angular diameter of the Sun's disk, seen from Earth, is 32'.
The angular diameter of the Sun seen from Saturn, is:

a) $\alpha_{\text{Sun-Saturn}} \approx 0.001$ radian b) $\alpha_{\text{Sun-Saturn}} \approx 0.002$ radian c) $\alpha_{\text{Sun-Saturn}} \approx 0.003$ radian d) $\alpha_{\text{Sun-Saturn}} \approx 0.004$ radian

Grid 7. Balls Suspended inside a Terrestrial Satellite

An artificial satellite moves around the Earth in a circular orbit with radius *r*. We observe the satellite at the position and orientation shown in figure 1. Inside the satellite are suspended, by very light wires, four identical spherical balls, each with mass *m*, such that the balls (b) and (c) are symmetrical to the ball (a), the balls (a) and (d) are symetrical to the ball (c), and the difference of their distances to the center of the Earth is $\Delta r = 2d$.

It is given: $M -$ the mass of the Earth; $G -$ gravitational attraction constant.

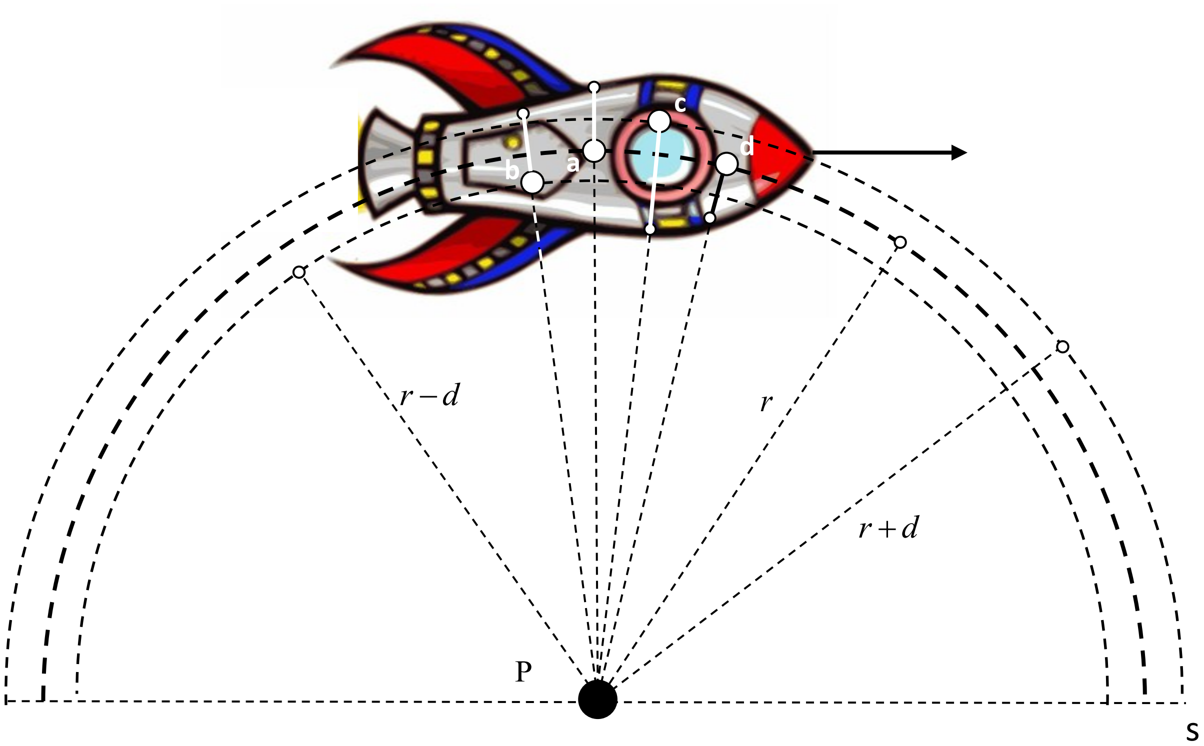


Fig. 1

The tension in each suspension wire, is:

a) $T_{(a)} = 0; T_{(b)} = 3G\frac{mMd}{r^3} > 0; T_{(c)} = 3G\frac{mMd}{r^3} > 0;\ T_{(d)} = 0$

b) $T_{(a)} = G\frac{mMd}{r^3};\ T_{(b)} = G\frac{mMd}{r^3} > 0;\ T_{(c)} = G\frac{mMd}{r^3} > 0;\ T_{(d)} = G\frac{mMd}{r^3}$

c) $T_{(a)} = 3G\frac{mMd}{r^3} > 0;\ T_{(b)} = 0;\ T_{(c)} = 0;\ T_{(d)} = 3G\frac{mMd}{r^3} > 0$

d) $T_{(a)} = 2G\frac{mMd}{r^3} > 0; T_{(b)} = 2G\frac{mMd}{r^3} > 0;\ T_{(c)} = 2G\frac{mMd}{r^3} > 0;\ T_{(d)} = 2G\frac{mMd}{r^3} > 0.$

Grid 8. Spaceship to the Sun

In a future program, NASA plans to launch a spacecraft, aimed directly at the Sun, without a human crew, to gather information, on its way to the Sun, both about all the inner planets and, in particular, about the Sun.

They are known: the distance Earth - Sun, $r_{ES} = 1.5\cdot 10^{11}$ m; the period of the Earth's rotation around the Sun, $T_E = 3.15\cdot 10^7$ s; the radius of the Sun, $R_S \approx \frac{r_{ES}}{200}$.

If the launch of the spacecraft will be done in such a way that its motion relative to the Sun is a free fall, then the approximate duration of the Earth-Sun flight is:

a) $t \approx 3.6 \cdot 10^5\ s$ b) $t \approx 6.6 \cdot 10^6\ s$ c) $t \approx 5.6 \cdot 10^6\ s$ d) $t \approx 4.6 \cdot 10^6\ s$

Grid 9. The Moon, seen on the way to the Moon

The full Moon, whose linear diameter is $d = 3\,436$ km, at Earth in the distance $r_0 = 384\,000\ km$, has the apparent magnitude $m_0 = -12.7$. The apparent magnitude of the Sun, seen from Earth, is $m_s = -26.84$. The distance, r, from the full Moon, where a cosmonaut is, on the way of his spaceship to the Moon, the magnitude of the full Moon should be 50% of the magnitude of the Sun as seen from Earth, is:

a) $r \approx 198\,243\ km\ ss$ b) $r \approx 320\,732\ km$ c) $r \approx 132\,521\ km$ d) $r \approx 275\,633\ km$

Grid 10. The luminosity of a star

The luminosity of a star Σ, is $L_\Sigma = 100 \cdot L_S$, where L_S is the luminosity of the Sun, and the star's surface temperature is $T_\Sigma = \frac{1}{2} \cdot T_S$, where T_S is the Sun's surface temperature.

Ratio between the radius of the star and the radius of the Sun is:

a) $\frac{R_\Sigma}{R_S} = 40;$ b) $\frac{R_\Sigma}{R_S} = 30;$ c) $\frac{R_\Sigma}{R_S} = 60;$ d) $\frac{R_\Sigma}{R_S} = 50.$